500 MW Solar Farm Proposal

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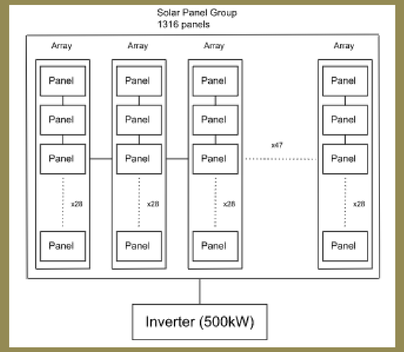
Project Overview

The goal behind this project is to design a solar farm capable of supplying power to the city of Ottawa based on a 500 MW Solar PV power plant.

An overview of all these systems will be provided within the report, including a financial analysis and estimated return period of the solar farm investment.

Layout of 500kW group



We need 1000 groups connected in parallel to build a 500 MW Solar Farm

Solar Panel Specs

Total 1,316,000 LG 380Q1C-V5 Solar panels are needed

Under Standard Test Condition:

Solar panel specifications (LG 380Q1C-V5)	
Cell Properties (Material/Type)	Monocrystalline/N-type
Maximum Power (Pmax)	380 W
Operating Voltage (Vmp)	37.4 V
Operating Current(Imp)	10.17 A
Model Dimensions (LxWxH)	1700mm x 1026mm x 40mm
Cell Configuration	60 Cells (6x10)
Glass (Thickness/Material)	2.8mm/Tempered Glass with AR Coating
Weight	17.5 KG
Open Circuit Voltage(Voc, ±5%)	49.9 V
Short Circuit Current(Isc, ±5%)	10.48 A

*Operating temperature between 40°C ~ +85°C

Output Calculations

Output Voltage for each Array	37.4 V x 28 = 1047.2 V
Output Current for each Array	10.17 ADC
Output Voltage for each Group	1047.2 VDC
Output Current for each Group	10.17 x 47 = 477.99 ADC
Output Power for each Array	10.65 KW
Output Power for each Group	500.55 KW

Required Space

Panels for 1 MW	2632
Dimensions Per Panel	1.7m x 1.02m
Area Per Panel	1.73 m^2
Area Per Array	48.36 m^2
Area Per Group	2,272.92 m^2
Area Per Cluster (1MW) (0.75m separation between each arrays, 15° tilt angle in panels, 2m separation between array sets)	9307 m^2
Area for 500MW Farm (including all substations and a control rooms)	5,260,913 m^2 ~1300 acres

Solar Farm Substation

Transformer Specs	
Apparent power (max) and nominal power	500 kW
Nominal Voltage	480 Y/ 600Y
Nominal Frequency	60 Hz
Harmonic Distortion	<3%
Inverter Specs	
Capacity	500KVA
Primary Voltage	480 Y 277
Secondary Voltage	208 Y 120
# of phases	3
Nominal Frequency	60 Hz

Financial Analysis

Components	Price (CAD)	Quantity	Total Cost(CAD)
Solar Panels	$625	1,316,000	$822,500,000
Land	$11,815/acre	1300 acres	$15,359,500
Inverter	$120,000	1000	$120,000,000
Transformers	$16,129	500	$8,064,500
Panel Mount	$1000	47,000	$47,000,000
Busbars	$2.52	12,000	$63,000
Wire/Cables	$0.47/ft	53,000 ft	$24,000
Labor (installation)	$4,000,000	-	$4,000,000
Yearly Maintenance	$3,000,000	-	$3,000,000
Total Cost			$1,020,011,000

Repayment

Electricity Produced Per Year (W)	500,550 kW
Electricity Produced Per Year (Wh)	600,660,000 kWh
Utility Cost	$0.15/kWh
Farm Gross Return/Year	$90,099,000
Payback Time	11.32 Years

Opportunity

This is a long-term investment which takes estimate 11.32 years to breakeven after which the farm will make an estimated $85 million in yearly profit.

Université d'Ottawa
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University of Ottawa
Faculty of Engineering

School of Electrical Engineering
and Computer Science

ELG4125 Design Module 1

Designing a Solar Farm

Submission: October 2, 2022

Group 17

Submitted by:

Nima Mehrjoonezhad - 300027431

Kaiy Yuan - 8617972

Project Overview

The goal behind this project is to design a solar farm capable of supplying power to the city of Ottawa based on a 500 MW Solar PV power plant. All component consideration will be taken into account, including total panels required, necessary inverters/transformers, secondary components, including wires, safety system and busbars all meeting required rating to withstand total loads expected.

An overview of all these systems will be provided within the report, including a financial analysis and estimated return period of the solar farm investment.

-> SOLAR PANEL SPECIFICATIONS

Panel used: LG 380Q1C-V5 produced by LG

Under Standard Test Condition:

Solar panel specifications (LG 380Q1C-V5)	
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-> DETERMINING THE REQUIRED NUMBER OF SOLAR PANELS

Total power of a cluster	1 MW
Average sunshine per day in Ottawa	3.29h/day
Expected energy production per year for every kW of solar panels (for Ottawa)	(1kW) x 3.29$\frac{hour}{day}$ x (365 $\frac{day}{year}$) = 1200kWh/year

Production ration	Between 1.3 to 1.6

Calculating number of panels:

Number of panels = system size / panel wattage

Therefore

$$number\ of\ panels\ per\ 1MW\ =\ 1MW/380W\ =\ 2631.579 \text{ panels}$$

We will take **2,632** panels in total

Solar Farm Configuration:

Total panels required to produce 1 MW cluster is approximately 2,632 panels accounting for efficiency. The cluster of 2,632 panels is split in two groups, each containing 1,316 panels. Further, the cluster of 1,316 panels is split into 47 arrays, each array containing 28 individual solar panels. Solar panels are connected in series to increase the voltage and arrays are connected in parallel to increase the current. This is then multiplied by 500 for the 500 MW farm. Combining to a total of **1,316,000 panels** for the entire farm.

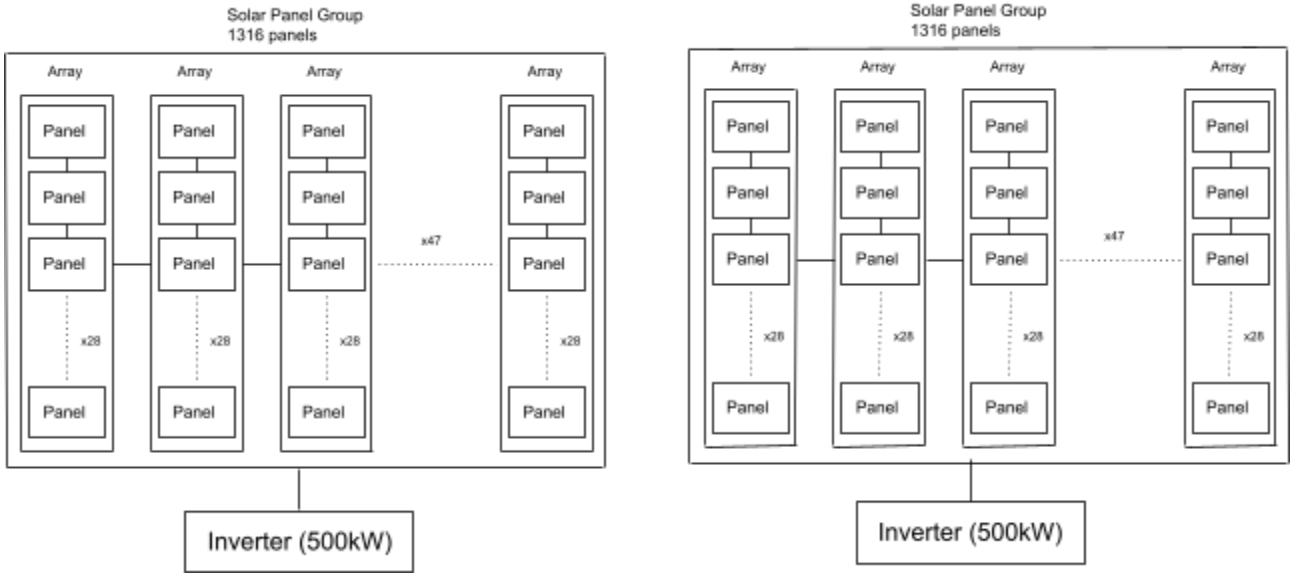

Figure 1- Block diagram of 1 MW cluster

-> OUTPUT CALCULATION

Panel boards in arrays are connected in series, arrays are connected in parallel.

Output Voltage for each Array	37.4 V x 28 = 1047.2 V
Output Current for each Array	10.17 ADC

Output Voltage for each Group	1047.2 VDC
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-> REQUIRED SPACE CALCULATION

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Area for 500MW Farm (including all substations and a control rooms)	5,260,913 m^2 ~1300 acres

-> FARM SUBSTATION

Solar Inverter Specification:

Input Data (DC):

DC Voltage (max. MPP)	600 V
Maximum Operating Input Current	1600 A
Open Circuit Turn on Voltage	330 V

Output Data (AC):

Apparent power (max) and nominal power	500 kW

Nominal Voltage	480 Y/ 600Y
Operating Voltage Range	-12% / +10%
Maximum Continuous Current	608 A
Nominal Frequency	60 Hz
Harmonic Distortion	<3%

AC output is 500kW therefore 2 inverters are needed for 1MW and 1,000 inverters are needed for 500MW.

Solar Transformer Specifications/Configuration:

Capacity	500KVA
Primary Voltage	480 Y 277
Secondary Voltage	208 Y 120
# of phases	3
Nominal Frequency	60 Hz

Configuration	Quantity	Rating
Medium Voltage Transformer	500	33 KVA - 500KVA
High Voltage Transformer	10	133KVA - 100 MVA

Busbar:

Positions	2
Nominal Voltage	32 V
Current Rating	275 A

Wires/Cables:
Solar Photonic Wire Specification:

Size	12 AWG
Voltage	1kV/2kV
Insulation Thickness	0.075 inches
Outside Diameter	0.25 inches
Weight	0.046 lbs/ft

-> Financial Analysis

Components	**Price (CAD)**	**Quantity**	**Total Cost(CAD)**
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Estimates Return Period: (1kW for 15 cent)

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Electricity Produced Per Year (Wh)	600,660,000 kWh
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